DISTRIBUTION AND CLASSIFICATION OF RED SOILS IN CHINA

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ABSTRACT

Red soils in China include latosols, lateritic red earths, red earths, and yellow earths and are mainly equivalent to Oxisols, Ultisols, and some Alfisols in the US Taxonomy. They cover an area of 102 million ha and are mainly distributed in the tropical and subtropical regions of China, including Hainan, Guangdong, Yunnan, Taiwan, Fujian, Guangxi, Jiangxi, Hunan, Sichuan, Guizhou, Zhejiang, and Anhui. Having been subjected to intensive weathering, these soils are usually dominated by variable charge minerals such as kaolinite and Fe and Al oxides. Most red soils in China are acidic, nutrient-deficient and low in organic matter and cation exchange capacity, partly because of soil erosion and intensive use.

1. INTRODUCTION

The term 'red soils' used in this article covers all the red soil sequences found in the tropical and subtropical regions of China, including latosols, lateritic red earths, red earths, yellow earths, and other soil groups of similar properties. They are equivalent to Oxisols, Ultisols and some of the Alfisols in the Soil Taxonomy of the USA. As the soils have been subjected to intensive weathering under tropical and subtropical climatic conditions, the base elements (K, Na Ca, and Mg) have been mostly leached out, as has part of the original Si content. On the other hand, there is a relative accumulation of Al and Fe mostly in the form of oxides and hydroxides. The dominant clay mineral in these soils is usually kaolinite, often accompanied by hematite, goethite and sometimes gibbsite.. These minerals carry both negative and positive charges, depending on pH. Thus, they are often called variable charge minerals and the soils whose clay fractions are dominated by these minerals are called variable charge soils (Sanchez, 1976). The variable charge soils differ from permanent charge soils, which are dominated by 2:1 layer silicate minerals such as montmorillonite. Cation exchange capacity (CEC) is generally low in the red soils and variable charge minerals and organic matter contribute 50 to 70 % of the total CEC (Baligar and Ahlrichs 1998). Exchangeable Al^{3+} and H^{+} constitute a large proportion of the total exchangeable cations (Na^{+}, K^{+}, Mg^{2+}, Ca^{2+}, Al^{3+}, H^{+}) in most

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of the red soils. Liming and application of organic matter are effective approaches for increasing the CEC and base saturation of these soils (Von Uexkull and Mutert, 1995).

Red soils are widely distributed in tropical and subtropical regions and potentially constitute one of the most important soil resources for food production in the world. In China, the red soil regions cover an area of 2.6 million km^2 in the tropical and subtropical climatic zones embracing 15 provinces and autonomous regions and accounting for over 20% of the country's total land area. The red soil regions have favorable climatic and biological resources, including an annual mean daily temperature of 17-26 ^0C and an active cumulative temperature (> 10 ^0C) of 5000 to 9000 degree-days, mean annual duration of sunshine 1500-2100 hours and mean annual solar irradiation 4200-5800 MJm^{-2}. Annual rainfall ranges from 1200 to 3000 mm with a distinct peak in spring (March - May) and early summer (June-July) followed by a late summer drought. The highly diversified physical conditions, abundant water, favorable temperature, adequate land and biological resources, have enabled the red soil regions to contribute greatly to the development of sustainable agriculture and to the economy of China. Thus, 42.7% of the grain and 75% of the rice are produced in these regions of China, which supports 43% of the country's population but accounts for only 27% of the nation's total cultivated land area.

The red soil regions are dominated by low mountains and hills, a landscape that with an uneven distribution of rainfall makes the agroecosystem of these regions very vulnerable to soil erosion. Moreover, these regions, being the most densely populated, are under great pressure to increase the area of arable land so as to meet the increasing demand for food and fibre. This demand is often achieved at the expense of deforestation of red soils, so that control of soil erosion becomes a most critical challenge in these regions of China. Soil erosion has resulted in a tremendous loss of nutrients and decline of soil fertility over the past decades.

In recent years, with the rapid development of industry, some red soils have become contaminated by heavy metals as a result of increased inputs from industrial sources. In addition, surface water contamination with nitrogen and phosphorus, which are exported from agricultural practices by means of soil erosion or leaching, has become a public issue of increasing concern. These problems pose new challenges to the utilization, management, and protection of red soil resources and to sustainable agricultural production in the red soil regions.

2. DISTRIBUTION AND CLASSIFICATION OF RED SOILS

Red soils occupy an area of 101.9 million ha in China and consist of four soil groups in the Chinese Soil Classification: Latosols, Lateritic red earths, Red earths, and Yellow earths (Table 1). These soils have a characteristic zonal distribution and

have a typical profile consisting of A-Bs (eluvial horizon)-Bv (plinthite or Fe and Mn concretion/hardpan horizon)-C (parent material). Lateritic red earths and Yellow earths have a much less developed Bv horizon due to their distribution in high plateau or mountainous areas that have not been subjected to water submergence. Some Latosols, Lateritic red earths, and Red earths lack a well-developed A horizon because of soil erosion effects, whereas some Yellow earths may have an "AB" transitional horizon due to long-term forestry (Table 2).

Table 1. Distribution and nutrient status of red soils in China

	Latosols	Lateritic Red Earths	Red Earths	Yellow Earths
Sub-Groups	Ortho latosols Yellowish latosols	Ortho-lateritic red earths Yellowish alteritic red earths Para-lateritic red earths	Ortho-red earths Yellowish red earths Brownish red earths Para-red earths	Ortho-yellow earths Grey yellow earths Bleached yellow earths Para-yellow earths
Area (mill.ha.)	3.04 0.89	14.73 2.96 0.09	30.73 17.43 2.76 5.98	20.96 <0.01 0.10 2.18
% of total red soil area	3.86	17.46	55.86	22.28
Distribution	Hainan Guangdong Yunnan Taiwan	Fujian Guangdong Guangxi Yunnan Taiwan	Jiangxi Hunan Guangdong Fujian Giangxi Yunnan Guizhou Sichuan Zhejiang Anhui	Mountainous areas of south China including Sichuan and Guizhou
Parent Materials	Basalt Sandstone Marine deposits	Granite,basalt, Shale and Quaternary red clay	Quaternary red clay, red sandstone, phyllite, granite and gneiss	Granite and sandstone
Clay Minerals	Kaolinite, gibbsite, hematite	Kaolinite, Fe and Al oxide minerals Al chlorite	Kaolinite, Fe and Al oxides, Al chlorites/vermiculite Illite	Kaolinite, vermiculite, gibbsite, goethite, Al chlorite
US Soil Taxonomy	Udox, Udult, Humult, Udox	Udult, Ochrult, Ochrept	Udult, Udalf, Ochrept	Udalf, Umbrept, Ochrept, Udent

The Latosols are mostly developed on the terraces of low hills in Hainan and the Leizhou Penninsula of Guangdong as well as the southern part of Yunnan and Taiwan, where high temperature and rainfall cause intensive weathering of minerals. Primary and secondary 2:1 clay minerals such as monmorillonite and illite were completely decomposed and kaolinite and gibbsite become the dominant clay minerals. The main iron oxide mineral is a highly crystallized form of hematite, giving a red or dark red color to the soils, and accompanied by minor amounts of goethite. Latosols account for approximately 4% of the total red soils of China. The parent materials on which the Latosols are developed include basalt, sandstone, and marine deposits. In some hilly or mountainous areas of higher humidity, the soils are more yellowish due to an increased proportion of goethite. These soils are called yellowish Latosols.

Table 2. Distribution and nutrient status of red soils in China

Soil Types/ Properties	Latosols	Lateritic red earths	Red earths	Yellow Earths
Profile	$AB_s B_v C$	A B C	$AB_s B_v C$	A (AB) B C
Clay (%)	40-60	30-40	25-40	15-30
pH	4.6-5.4	5.0-5.5	4.2-5.9	4.5-5.5
SOM (g kg^{-1})	18-25	12-23	20-55	40-80
CEC ($cmol_c$ kg^{-1})	2.8-12.6	5.4-11.7	5.3-8.9	10.0-20.0
Base Sat. (%)	15-20	20-30	15-25	15-60
Total N. (g kg^{-1})	0.5-1.2	0.8-1.5	1.4-2.0	1.8-3.3
Total P (g kg^{-1})	0.3-1.5	0.5-0.9	0.6-0.9	0.5-1.9
Total K (g kg^{-1})	0.5-6.4	15-25	15-20	11-26
Hydrol.N (mg kg^{-1})	25-170	NA	60-170	NA
Avail. P (mg kg^{-1})	2-10	2-9	2-4	NA
Avail. K (mg kg^{-1})	31-65	50-130	37-120	NA

The lateritic red earths, accounting for about 17% of the total red soils, are mainly distributed in areas bordering between the tropical and subtropical regions of China including the west and southeast parts of Guangdong, southwest part of Guangxi, south part of Fujian and Taiwan, and southeast part of Yunnan. They are the transitional soil types between the Latosols and the Red earths that were subjected to less intensive weathering under subtropical climate conditions. These soils are derived mainly from granite, shale, basalt, and quaternary red clay. Mica and feldspar tend to decrease and kaolinite and Fe and Al oxides are the dominant clay minerals with minor amount of Al-chlorite (Table 1). This lateritic soil group has three sub-groups: lateritic red earths, yellowish lateritic red earths, and para-lateritic red earths, with slightly decreased weathering intensity.

The red earths, which account for approximately 56% of the total red soil area, are the dominant highly weathered soil type in China. This soil group consists of four subgroups including red earths, yellowish red earths, brownish red earths, and sub-red earths. They are widely distributed in the hilly and mountainous regions to the south of Yangtze river, including most parts of Jiangxi and Hunan, northern part of Yunnan, Guangdong, Guangxi, and Fujian, southern part of Quizhou, Sichuan, Zhejiang, and Anhui. The major parent materials from which the red earths were derived include Quaternary red clay, limestone, shale, tuff, phyllite, granite, and gneiss. Kaolinite, Fe and Al oxides are often the dominant clay minerals in the red earths, but occasionally, there are also small amounts of Al-chlorite, illite, and Al-vermiculite.

The yellow earths are found in the mountainous regions of south China, distributed mostly in tropical and subtropical mountain lands of Sichuan, Quizhou, and other provinces, with high humidity and rainfall. These soils are mainly developed on granite and sandstone and contain considerable amounts of vermiculite, Al- chlorite, and illite, in addition to kaolinite and Fe and Al oxides. Goethite is the dominant Fe oxide mineral and gibbsite the major Al oxide mineral (Table 1).

To facilitate understanding of the red soils, soil classification names under the US Soil Taxonomy, which are equivalent to each sub-groups of the red soils, are also provided in Table 1. There is an apparent difference in the use of standards for soil classification between the US and Chinese systems so that the soil classification equivalents may not be precise.

3. REFERENCES

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